

INFRARED SPECTROSCOPY FOR GEOLOGIC INTERPRETATION OF TIMS DATA

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Some spectroscopic techniques yield more information directly applicable to the interpretation of TIMS data than others. Clearly, the most meaningful spectra are those collected in the field under climatic, thermal and sky conditions that approximate those at the time of the overflight. The Portable Field Emission Spectrometer, PFES, was designed by JPL with that purpose in mind. It makes normal spectral radiance measurements of the target from 5 to 14 micrometers, has a spectral resolution of approximately 0.2 micrometer, and has an instantaneous field of view of 2 degrees by 10 degrees. The large field of view of the PFES as compared to that readily obtainable in the laboratory with reflectance or emittance instruments makes it indispensable in spectrally analyzing targets with texture or character that varies on a scale greater than one inch.

A team of 3 to 4 people in addition to a small van load of supporting equipment is required to operate the PFES in the field. The spectrometer optics and data reduction system are mounted on backpack frames and day long spectra and sample collecting trips can be undertaken in rough terrane. A number of sedimentary and igneous rocks, all from the western United States have been analyzed.

PFES data reduction is carried out at JPL on a VAX 750. Typically, a target's absolute spectral radiance is determined, a theoretical black body curve, given by Plank's Law, is fit to the data and some measure of the sample's spectral emissivity is found by ratioing the target's spectral radiance to the spectral radiance of the black body.

Two factors have led to interest in laboratory reflectance measurements of rocks and minerals for the purposes of interpreting TIMS data. The first is the cumbersome nature of the PFES, and the second is the tight experimental control available in the laboratory in terms of some of the environmental factors that influence the spectral emission of earth surface materials. The ability to measure total hemispherical reflectance is particularly desirable because data collected at nadir is directly related to the normal spectral emittance of the target by Kirchoff's Law. Strictly specular or diffuse reflectance measurements are not directly related to normal spectral emittance because the geometry of the measurement influences the shape and intensity of absorption features of samples which show wavelength dependent scattering behavior, for example, quartz, Becker et al., 1985.

Nonetheless, I have found the agreement between the bi-conical diffuse reflectance of weathered surfaces of rocks measured in the laboratory and normal spectral emittance of the same samples determined with PFES data to be reasonably good. The positions and shapes but not the absolute

intensities of the absorption features in that they occur in both kinds of spectra agree. The reflectance measurements occasionally reveal absorptions not appearing in and/or lost in the noise of the lower resolution PFES spectra. It is encouraging that bi-conical reflectance attachments provide valuable band shape and position information because integrating spheres required for total hemispherical measurements are custom designed and custom built items while bi-conical devices are commonly commercially available under the name of diffuse reflectance attachments.

The future of infrared spectroscopy for geologic interpretation of TIMS data includes the direct laboratory measurement of the normal spectral radiance of earth surface materials at low temperatures (20 to 30 degrees centigrade). We are currently developing this capability at JPL and almost all of the equipment needed has been bought or built and installed. An initial calibration effort is awaiting software development. The major components of the system include a commercially built Fourier Transform infrared spectrometer (the same one used for reflectance measurements), a custom designed sample accessory which is necessary to shield the sample from background radiation and reference blackbodies.

The reflectance measurements of weathered surfaces of rocks that I have made to date have confirmed previous suspicions about the complexity of the spectra of these kind of samples. In particular, heavily weathered or heavily varnished surfaces of rocks have different spectra than the fresh broken surfaces of the same rocks. These observations reemphasize the need to understand the influences of varnish, surface roughness, mineralogy, and particle size on the spectra of naturally occurring rock and mineral surfaces if we are to fully utilize TIMS data to solve geologic problems.

Reference

Becker, F., Ramanatsizehena, P., and Stoll, M.-P., 1985. Angular variation of the bidirectional reflectance of bare soils in the thermal infrared band. *Applied Optics*, 24, 365-375.

*The research described in this abstract was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.